



Patent
Attorney's Docket No. 024444-747

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

UTILITY PATENT
APPLICATION TRANSMITTAL LETTER

Box PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231



Sir:

Enclosed for filing is the utility patent application of Anders LENANDER al. for CEMENTED CARBIDE INSERT.

Also enclosed are:

- ☒ One sheet of ☐ formal ☐ informal drawing(s);
- ☒ a claim for foreign priority under 35 U.S.C. §§ 119 and/or 365 is ☒ hereby made to SE 9901243-7 filed in SWEDEN on April 8, 1999;
☒ in the declaration;
- ☐ a certified copy of the priority document;
- ☐ a General Authorization for Petitions for Extensions of Time and Payment of Fees;
- ☐ _____ statement(s) claiming small entity status;
- ☐ an Assignment document;
- ☐ an Information Disclosure Statement; and
- ☐ Other: _____
- ☒ An ☐ executed ☒ unexecuted declaration of the inventor(s)
☒ also is enclosed ☐ will follow.
- ☐ Please amend the specification by inserting before the first line the sentence --This application claims priority under 35 U.S.C. §§119 and/or 365 to _ filed in _ on _; the entire content of which is hereby incorporated by reference.--
- ☐ A bibliographic data entry sheet is enclosed.



21839

[x] The filing fee has been calculated as follows [] and in accordance with the enclosed preliminary amendment:

C L A I M S					
	NO. OF CLAIMS		EXTRA CLAIMS	RATE	FEE
Basic Application Fee					\$690.00 (101)
Total Claims	23	MINUS 20 =	3	x \$18.00 (103)	\$54.00
Independent Claims	2	MINUS 3 =	0	x \$78.00 (102)	0
If multiple dependent claims are presented, add \$260.00 (104)					
Total Application Fee					\$744.00
If verified Statement claiming small entity status is enclosed, subtract 50% of Total Application Fee					
Add Assignment Recording Fee of if Assignment document is enclosed					
TOTAL APPLICATION FEE DUE					\$744.00

[] This application is being filed without a filing fee. Issuance of a Notice to File Missing Parts of Application is respectfully requested.

[x] A check in the amount of \$ 744.00 is enclosed for the fee due.

[] Charge \$ _____ to Deposit Account No. 02-4800 for the fee due.

[x] The Commissioner is hereby authorized to charge any appropriate fees under 37 C.F.R. §§ 1.16, 1.17 and 1.21 that may be required by this paper, and to credit any overpayment, to Deposit Account No. 02-4800. This paper is submitted in duplicate.

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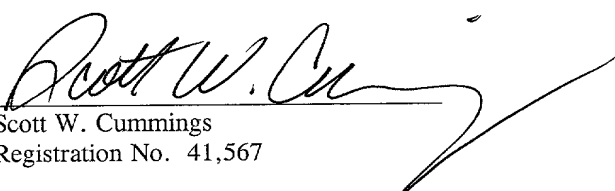
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002044-747

UNITED STATES PATENT APPLICATION

OF

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FOR

CEMENTED CARBIDE INSERT

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CEMENTED CARBIDE INSERT**BACKGROUND OF THE INVENTION**

5 The present invention relates to a coated cemented carbide cutting tool insert particularly useful for turning operations in steels or stainless steels, and is especially suited for operations with high demands regarding toughness properties of the insert.

10 High performance cutting tools must nowadays possess high wear resistance, high toughness properties and good resistance to plastic deformation. Improved toughness behaviour of a cutting insert can be obtained by increasing the WC grain size and/or by raising the overall binder phase content, but such changes will simultaneously result in significant loss of the plastic deformation resistance.

15 Methods to improve the toughness behaviour by introducing an essentially gamma phase-free and binder phase-enriched surface zone with a thickness of about 20-40 μm on the inserts by so-called "gradient sintering" techniques have been known for some time e.g. US 4,277,283, US 4,497,874, US 4,548,786, US 4,640,931, US 5,484,468, US 5,549,980, US 5,649,279, US 5,729,823. The characteristics of these patents are that the surface zone has a different composition than the bulk composition, and is depleted of gamma phase and binder phase enriched.

20 **SUMMARY OF THE INVENTION**

It has now surprisingly been found that by using a gamma phase consisting essentially of only TaC and TiC in addition to WC, by keeping the ratio between the elements Ta and Ti within specific limits, and having a highly W-alloyed binder phase, the toughness properties of the gradient sintered cutting inserts can be significantly improved without any loss of plastic deformation resistance.

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5 A first aspect of the present invention provides a cutting tool insert for machining steel comprising a cemented carbide body comprising WC, 5-12 wt. % Co, 3-11 wt. % of cubic carbides of the metals Ta and Ti, and less than 0.1 wt. % of Nb where the ratio of Ta/Ti is 1.0-4.0, and the Co-binder phase is highly alloyed with W, having a CW-ratio of 0.75-0.95, the body also comprising a binder phase enriched and essentially gamma phase free surface zone with a thickness of 5-50 μm ; and a coating.

10 A second aspect of the present invention provides a method of making a coated cemented carbide body having a gamma phase-free and binder rich surface zone comprising the steps of:

- (i) forming a powder mixture comprising WC, 5-12 wt. % Co, 3-11 wt. % cubic carbides of Ta and Ti, where the ratio of Ta/Ti is 1.0-4.0;
- (ii) adding N in an amount of 0.6-2.0% of the weight of Ta and Ti;
- (iii) milling and spray drying the mixture to form a powder material with the desired properties;
- (iv) compacting and sintering the powder material at a temperature of 1300-1500°C, in a controlled atmosphere of about 50 mbar followed by cooling, whereby a body having a binder phase enriched and essentially gamma phase free surface zone of 5-50 μm in thickness is obtained;
- (v) applying a pre-coating treatment to the body; and
- (vi) applying a hard, wear resistant coating.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 is a plot showing the level of Co enrichment near the surface of an insert formed according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

According to the present invention there is now provided a coated cemented carbide insert with a 5-50 μm thick, preferably 10-30 μm thick, essentially gamma phase free and binder phase-enriched surface zone with an average binder phase content (by volume) preferably in the range 1.2-2.0 times the bulk binder phase content.

The gamma phase consists essentially of TaC and TiC and of any WC that dissolves into the gamma phase during sintering. The ratio Ta/Ti is between 1.0 and 4.0, preferably 2.0-3.0.

The binder phase is highly W-alloyed. The content of W in the binder phase can be expressed as a

$$\text{CW-ratio} = M_s / (\text{wt. Co} * 0.0161) \text{ where}$$

M_s is the measured saturation magnetization of the cemented carbide body in kA/m and wt-% Co is the weight percentage of Co in the cemented carbide. The CW-ratio takes a value less than or equal to 1. The lower the CW-ratio, the higher the W-content in the binder phase. It has now-been found according to the invention that an improved cutting performance is achieved if the CW-ratio is in the range 0.75-0.95, preferably 0.80-0.85.

The present invention is applicable to cemented carbides with a composition of 5-12, preferably 9-11, weight percent of Co binder phase, and 3-11, preferably 7-10, weight percent TaC + TiC, and the balance being WC. The Nb content should not exceed 0.1 weight percent. The weight ratio Ta/Ti should be 1.0-4.0, preferably 2.0-3.0. The WC preferably has an average grain size of 1.0 to 4.0 μm , more preferably 1.5 to 3.0 μm . The cemented carbide body may contain less than 1 volume % of η -phase (M_6C).

Inserts according to the invention are further provided with a coating preferably comprising 3-12 μm columnar TiCN-layer followed by a 1-8 μm thick Al_2O_3 -layer deposited, for example, according to any of the patents US 5,766,782,

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US 5,654,035, US 5,974,564, US 5,702,808, preferably a κ - Al_2O_3 -layer and preferably with an outermost thin layer of TiN which preferably is removed in the edge line by brushing or by blasting.

According to the invention, by applying coatings with different thickness on
5 the cemented carbide body the property of the coated insert can be optimised to suit specific cutting conditions.

In one embodiment, a cemented carbide insert produced according to the invention is provided with a coating of: $6\text{ }\mu\text{m}$ TiCN, $5\text{ }\mu\text{m}$ Al_2O_3 and $1\text{ }\mu\text{m}$ TiN. This coated insert is particularly suited for cutting operation in steel.

10 In another embodiment, a cemented carbide insert produced according to the invention is provided with a coating of: $4\text{ }\mu\text{m}$ TiN, $2\text{ }\mu\text{m}$ Al_2O_3 and $1\text{ }\mu\text{m}$ TiN. This coating is particularly suited for cutting operations in stainless steels.

The invention also relates to a method of making cutting inserts comprising a cemented carbide substrate of a binder phase of Co, WC, a gamma phase of Ta and Ti, a binder phase enriched surface zone essentially free of gamma phase, and
15 a coating. A powder mixture containing 5-12, preferably 9-11, weight percent of binder phase consisting of Co, and 3-11, preferably 7-10, weight percent TaC + TiC, and the balance WC with an average grain size of $1.0 - 4.0\text{ }\mu\text{m}$, more preferably $1.5-3.0\text{ }\mu\text{m}$, is prepared. The Nb content should not exceed 0.1 weight
20 percent. The weight ratio Ta/Ti should be 1.0-4.0, preferably 2.0-3.0. Well-controlled amounts of nitrogen have to be added either the powder as carbonitrides and/or added during the sintering process via the sintering gas atmosphere. The amount of nitrogen added will determine the rate of dissolution of the cubic phases during the sintering process and hence determine the overall distribution of the
25 elements in the cemented carbide after solidification. The optimum amount of nitrogen to be added depends on the composition of the cemented carbide and, in particular, on the amount of cubic phases and varies between 0.6 and 2.0% of the weight of the elements Ti and Ta. The exact conditions depend to a certain extent

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on the design of the sintering equipment being used. It is within the purview of the skilled artisan to determine whether the requisite surface zone of the cemented carbide have been obtained and to modify the nitrogen addition and the sintering process in accordance with the present specification in order to obtain the desired result.

The raw materials are mixed with pressing agent and, optionally W, such that the desired CW-ratio is obtained. The mixture is milled and spray dried to obtain a powder material with the desired properties. Next, the powder material is compacted and sintered. Sintering is performed at a temperature of 1300-1500°C, in a controlled atmosphere of about 50 mbar followed by cooling. After conventional post sintering treatments, including edge rounding, a hard, wear resistant coating according to above is deposited by CVD- or MT-CVD-technique.

Example 1

A.) Cemented carbide turning inserts of the style CNMG 120408-PM and SNMG120412-PR with the composition 9.9 wt% Co, 6.0 wt% TaC, 2.5 wt% TiC, and 0.3 wt% TiN, with the balance WC having an average grain size of 2.0 μm were produced according to the invention. The nitrogen was added to the carbide powder as TiCN. Sintering was done at 1450°C in a atmosphere of Ar at a total pressure of about 50 mbar.

Metallographic investigation showed that the inserts had a gamma phase free zone of 15 μm . Fig.1 shows a plot of the Co enrichment near the surface measured by an image analysis technique. The Co is enriched to a peak level of 1.3 times the bulk content. Magnetic saturation values were recorded and used for calculating CW-values. An average CW-value of 0.81 was obtained.

After a pre-coating treatment like edge honing, cleaning etc. the inserts were coated in a CVD-process comprising a first thin layer (less than 1 μm) of TiN followed by 6 μm thick layer of TiCN with columnar grains by using MTCVD-

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techniques (process temperature 850 °C and CH₃CN as the carbon/nitrogen source). In a subsequent process step during the same coating cycle, a 5 μm thick κ-Al₂O₃ layer was deposited according to US Patent 5,974,564. On top of the κ-Al₂O₃ layer a 1.0 μm TiN layer was deposited. The coated inserts were brushed in order to smoothly remove the TiN coating from the edge line.

B.) Cemented carbide turning inserts of the style CNMG 120408-PM and SNMG120412-PR with the composition 10.0 wt% Co, 2.9 wt% TaC, 3.4 wt% TiC, 0.5 wt% NbC and 0.2 wt% TiN and the balance WC with an average grain size of 2.1 μm were produced. The inserts were sintered in the same process as A. Metallographic investigation showed that the produced inserts had a gamma phase free zone of 15 μm. Magnetic saturation values were recorded and used for calculating CW-values. An average CW-value of 0.81 was obtained. The inserts were subject to the same pre-coating treatment as A, coated in the same coating process and also brushed in the saute way as A.

C.) Cemented carbide turning inserts of the style CNMG 120408-PM and SNMG120412-PR with the composition 10.0 wt% Co, 3.0 wt% TaC, 6.3 wt% ZrC and balance WC with an average grain size of 2.5 μm were produced.

Metallographic investigation showed that the produced inserts had a gamma phase free zone of 12 μm. Magnetic saturation values were recorded and used for calculating CW-values. An average CW-value of 0.79 was obtained. The inserts were subject to the same pre-coating treatment as A, coated in the same coating process and also brushed in the same way as A.

Example 2

Inserts from A, B and C were tested with respect to toughness in a longitudinal turning operation with interrupted cuts.

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Material; Carbon steel SS1312.

Cutting data:

Cutting speed 130 m/min

Depth of cut 1.5 mm

5 Feed = Starting with 0.15 mm and gradually increased by 0.10 mm/min
until breakage of the edge

8 edges of each variant were tested

Inserts style: CNMG120408-PM

Results:

10		Mean feed at breakage
	Inserts A	0.31 mm/rev
	Inserts B	0.22 mm/rev
	Inserts C	0.22 mm/rev

Example 3

15 Inserts from A, B and C were tested with respect to resistance to plastic
deformation in longitudinal turning of alloyed steel (AISI 4340).

Insert style: CNMG 120408-PM

Cutting data:

	Cutting speed =	100 m/min
20	Feed =	0.7 mm/rev.
	Depth of cut =	2 mm
	Time in cut =	0.50 min

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The plastic deformation was measured as the edge depression at the nose of the inserts.

Results:

		Edge depression, μm
5	Insert A	49
	Insert B	63
	Insert C	62

Example 4

Tests performed at an end user producing rear shaft for lorries. The inserts from A and C were tested in a three turning operations with high toughness demands due to interrupted cuts. The inserts were run until breakage of the edge. The insert style SNMG120412-PR was used. Results:

		<u>Number of machined components</u>		
	Operation	1	2	3
15	Variant A	172	219	119
	Variant C	20	11	50

Examples 2, 3 and 4 show that the inserts A according to the invention surprisingly exhibit much better toughness in combination with somewhat better plastic deformation resistance in comparison to conventional inserts B and C.

The foregoing has described the principles, preferred embodiments and modes of operation of the present invention. However, the invention should not be construed as being limited to the particular embodiments discussed. Thus the above-described embodiments should be regarded as illustrative rather than restrictive, and it should be appreciated that variations may be made in those embodiments by workers skilled in the art without departing from the scope of the present invention as defined by the following claims.

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WE CLAIM:

1. A coated cemented carbide body comprising:
a gamma phase consisting essentially of TaC, TiC and WC, wherein the ratio of Ta/Ti is 1.0-4.0, the body having a CW ratio of 0.75-0.95, the CW ratio expressed as:
CW ratio = $M_s / (\text{wt. \% Co} * 0.0161)$, wherein M_s is the measured saturation magnetization of the body and wt. % Co is the weight percentage of Co in the cemented carbide, the body further comprising a surface zone that is essentially gamma phase-free and is binder rich.
2. The coated body of claim 1, wherein the surface zone is approximately 5-50 μm thick.
3. The coated body of claim 1, wherein the surface zone is approximately 10-30 μm thick.
4. The coated body of claim 1, wherein the surface zone has a binder phase content 1.2-2.0 times the binder phase content in the rest of the body.
5. The coated body of claim 1, wherein the Ta/Ti-ratio is 2.0-3.0.
6. The coated body of claim 1, wherein the CW ratio is 0.80-0.85.
7. The coated body of claim 1, wherein the body comprising Co content of 5-12 wt. %.
8. The coated body of claim 7, wherein the Co content is 9-11 wt. %.

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9. The coated body of claim 1, wherein the combined content of TaC and TiC is 3-11 wt. %.

10. The coated body of claim 9, wherein the combined content of TaC and TiC is 7-10 wt. %.

5 11. The coated body of claim 1, wherein the body comprises WC having a grain size of 1.0-4.0 μm .

12. The coated body of claim 11, wherein the grain size is 1.5-3.0 μm .

13. A coated body of claim 1, wherein said coating comprises a 3-12 μm columnar TiCN-layer, followed by a 1-8 μm thick Al_2O_3 -layer.

10 14. The coated body of claim 13, wherein the said Al_2O_3 -layer is κ - Al_2O_3 .

15. The coated body of claim 13, wherein the coating comprises an outermost layer of TiN.

15 16. The coated body of claim 14, wherein the coating comprises an outermost layer of TiN.

17. The coated body of claim 15, having no TiN layer at an edge line of the body.

18. The coated body of claim 1, wherein the coated body comprises a cutting tool insert having at least one cutting edge.

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19. A method of making a coated cemented carbide body having a gamma phase-free and binder rich surface zone comprising the steps of:

(i) forming a powder mixture comprising WC, 5-12 wt. % Co, 3-11 wt. % cubic carbides of Ta and Ti, where the ratio of Ta/Ti is 1.0-4.0;

5 (ii) adding N in an amount of 0.6-2.0% of the weight of Ta and Ti;

(iii) milling and spray drying the mixture to form a powder material with the desired properties;

10 (iv) compacting and sintering the powder material at a temperature of 1300-1500°C, in a controlled atmosphere of about 50 mbar followed by cooling, whereby a body having a binder phase enriched and essentially gamma phase free surface zone of 5-50 μm in thickness is obtained;

(v) applying a pre-coating treatment to the body; and

(vi) applying a hard, wear resistant coating.

20. The method of claim 19, further comprising adding a pressing agent and W to the powder mixture in an amount to give the body a CW ratio of 0.75-0.95, the CW ratio is expressed as $CW \text{ ratio} = M_s / (\text{wt. \% Co} * 0.0161)$, where M_s is the measured saturation magnetization of the body and wt. % Co is the weight percentage of Co in the cemented carbide.

21. The method according to claim 19, wherein the powder mixture comprises 7-10 wt. % of cubic carbides of the metals Ta and Ti.

22. The method according to claim 19, wherein the coating is applied using a CVD-technique.

23. The method according to claim 19, wherein the coating is applied using a MT-CVD-technique.

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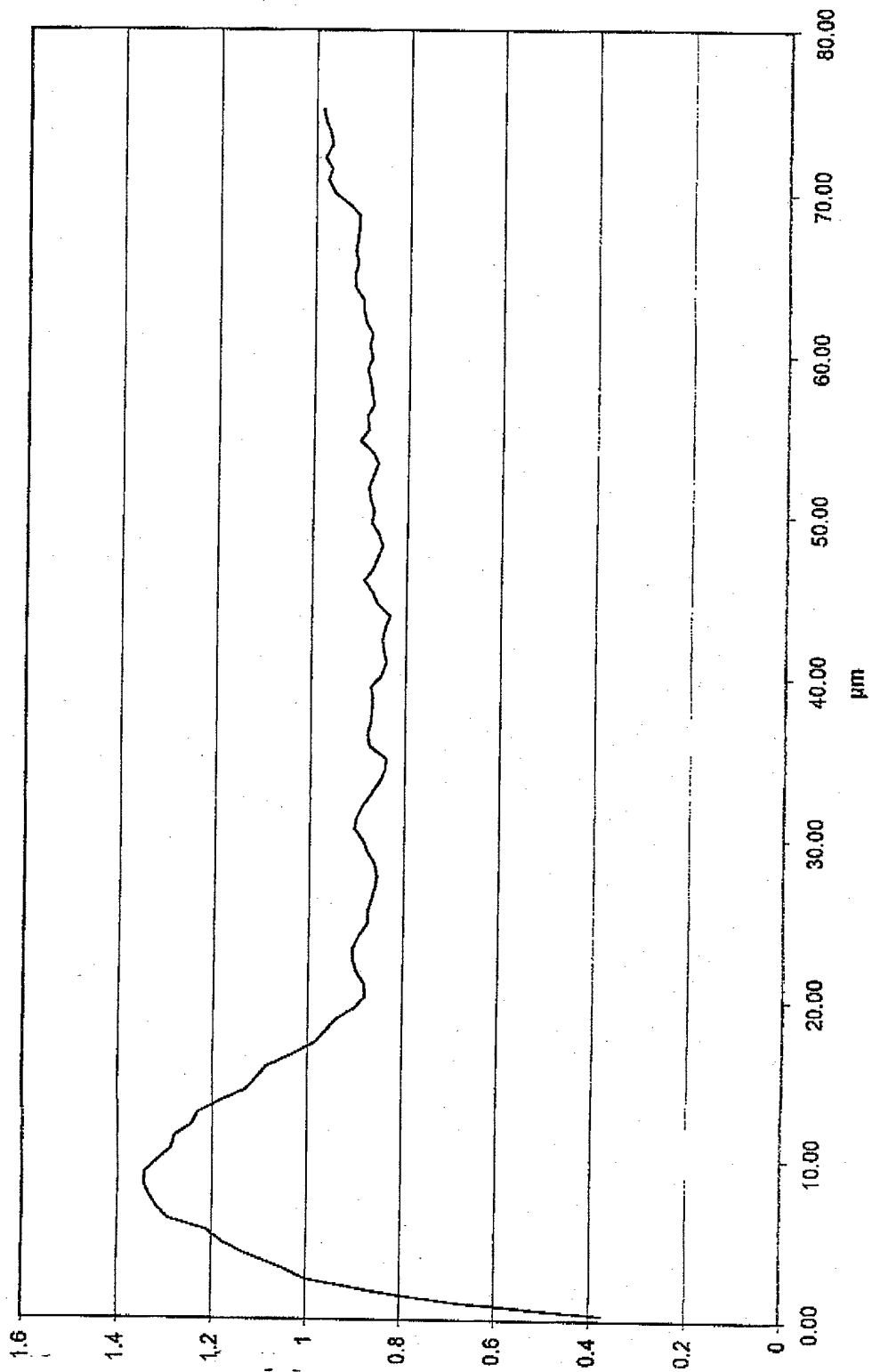
Abstract of the Disclosure

5 The present invention relates to a cutting tool insert and its methods of manufacture for machining of steel comprising a cemented carbide body and a coatings. The cemented carbide body includes WC, 5-12 wt-% Co and 3-11 wt-% of cubic carbides of metals Ta and Ti. The amount of Nb is below 0.1 wt-% and the ratio Ta/Ti is 1.0-4.0. The Co-binder phase is highly alloyed with W with a CW-ratio of 0.75-0.95 and, finally, the cemented carbide body has a binder phase enriched and essentially gamma phase free surface zone of a thickness of 5-50 μm .

002070" etthst50

002040" Strickland

Fig.1



**COMBINED DECLARATION AND POWER OF ATTORNEY
FOR UTILITY PATENT APPLICATION**

Attorney's Docket No.
024444-747

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I BELIEVE I AM THE ORIGINAL, FIRST AND SOLE INVENTOR (if only one name is listed below) OR AN ORIGINAL, FIRST AND JOINT INVENTOR (if more than one name is listed below) OF THE SUBJECT MATTER WHICH IS CLAIMED AND FOR WHICH A PATENT IS SOUGHT ON THE INVENTION ENTITLED:

CEMENTED CARBIDE INSERT

the specification of which

(check one)

☒ is attached hereto;

☐ was filed on _____ as

Application No. _____

and was amended on _____;
(if applicable)

I HAVE REVIEWED AND UNDERSTAND THE CONTENTS OF THE ABOVE-IDENTIFIED SPECIFICATION, INCLUDING THE CLAIMS, AS AMENDED BY ANY AMENDMENT REFERRED TO ABOVE;

I ACKNOWLEDGE THE DUTY TO DISCLOSE TO THE OFFICE ALL INFORMATION KNOWN TO ME TO BE MATERIAL TO PATENTABILITY AS DEFINED IN TITLE 37, CODE OF FEDERAL REGULATIONS, Sec. 1.56 (as amended effective March 16, 1992);

I do not know and do not believe the said invention was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to said application; that said invention was not in public use or on sale in the United States of America more than one year prior to said application; that said invention has not been patented or made the subject of an inventor's certificate issued before the date of said application in any country foreign to the United States of America on any application filed by me or my legal representatives or assigns more than twelve months prior to said application;

I hereby claim foreign priority benefits under Title 35, United States Code Sec. 119 and/or Sec. 365 of any foreign application(s) for patent or inventor's certificate as indicated below and have also identified below any foreign application for patent or inventor's certificate on this invention having a filing date before that of the application(s) on which priority is claimed:

COMBINED DECLARATION AND POWER OF ATTORNEY

Attorney's Docket No.
024444-747

COUNTRY/INTERNATIONAL	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED
SWEDEN	9901243-7	April 8, 1999	YES <u>x</u> NO <u> </u>
			YES <u> </u> NO <u> </u>

I hereby appoint the following attorneys and agent(s) to prosecute said application and to transact all business in the Patent and Trademark Office connected therewith and to file, prosecute and to transact all business in connection with international applications directed to said invention:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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